User's guide for the BET-Tephra@OV software package

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BET-Tephra@OV is a Python software package to compute and visualize long- and short- term eruption forecasting and probabilistic tephra hazard assessment of Campi Flegrei caldera. The tool is based on the procedure described by Selva et al. (2014) that combines the Bayesian Event Tree method (Marzocchi et al. 2008; 2010) and on the Fall3D tephra dispersal model (Costa et al. 2006; Folch et al., 2009).

It was realized by Dr. Perfetti with the contributions by Dr. Costa, Dr. Selva, Dr. Sandri, Dr. Macedonio, and Dr. Tonini, in the framework of the Italian Civil Protection Department (DPC) - INGV Research Project *"OBIETTIVO 5 (V2): Implementazione nell'ambito delle attività di sorveglianza del vulcano Campi Flegrei di una procedura operativa per la stima in tempo quasi reale della probabilità di eruzione, probabilità di localizzazione della bocca eruttiva, e probabilità di accumulo delle ceneri al suolo in caso di eruzione di tipo esplosivo"*, 2014-2015 (Responsible Dr. Giuseppe De Natale, Director of INGV - Osservatorio Vesuviano, Napoli), under the Coordination of Dr. Antonio Costa (INGV, Bologna).

The software package is composed of different components that are designed to:

1. gathering available monitoring parameter values,
2. downloading and converting data from weather forecast,
3. evaluating the state of the volcano (eruption forecasting) based on monitoring and long-term information, including the position of the vent (in probabilistic terms),
4. estimating the tephra load distribution (for the three different eruption sizes and in probabilistic terms).

The main program execution (update of parameter gathering, probabilistic estimation of pre-eruptive and eruptive stages, tephra load modelling and statistical mixing of long- and short-term data) is scheduled regularly. In case of a low to moderate volcanic activity, the execution is launched every 12 hours.

The web interface component displays a bar on the top showing the last run (reporting execution date and time), and allowing the selection of the results achieved at previous simulations by using the right/left arrows (rendered on web page only if successive/previous runs are available). The main page contains multiple tabs:

1. Overview

This is the main visualization, divided into 2 main sections: **State of the Volcano** and **Tephra Hazard Assessment**.

- State of the Volcano*:* this section (light green background colour) displays a list consisting of a summary of the anomalies in the monitored parameters (on the left side). The central plots display the temporal evolution of conditional probabilities for ***Unrest*****,** ***Magmatic Unrest,*** and ***Eruption*** for the last 30 days, computed adopting the method presented in Selva et al. (2012a) with the elicitation parameters updated in 2015. ***The values refer to the monthly absolute probabilities of each node***. Further information, including the detailed parameter values retrieved from the monitoring network, is presented in the dedicated tab **Parameters** (see below).
The plot on the right side shows the **conditional probability map of vent opening locations**, based on the statistical mixing of the short- and long-term maps. The former is based on the localization of detected anomalies (if any) in the parameters that are deemed as relevant in informing the position of the vent. The latter is based on historical, geological and morphological data (Selva et al., 2012b).

- Tephra Hazard Assessment: in this section (light yellow background colour), three maps are shown, representing different tephra load distributions.
The plot on the left side (***Predicted tephra loading***) shows the tephra loading associated to a medium size eruption (e.g., the reference scenario for the DPC) from the caldera centre simulated using the Fall3d model (maps relative to other sizes are available by clicking on the second tab "**Fall3d**", see below). The central plot shows the ***Mean hazard map(*) at 5% of conditional exceedance probability*** (conditional to the occurrence of one eruption of whatever size in whatever vent position) calculated over the selected 24 hours interval. The plot on the right side describes the ***Mean hazard map(*) at 1% of absolute exceedance probability*** calculated over the selected 24 hours interval.

- The ***Time offset*** menu, next to the section title on the left side, gives the possibility to switch over different forecast intervals.

2. Fall3d: this tab collects the maps created by the Fall3d program execution, for three different eruption sizes (Small, Medium, Large) and time offsets (24-48), assuming a vent at the centre of the caldera. Model runs use the available weather forecast data, downloaded on demand from the ARPA-SIM servers; the simulations are executed independently from the BET suite. Also in this tab it is possible to choose the time offset, exploring tephra loading simulations over a few days.

3. Parameters: in this tab, the values of the monitored parameters and thresholds configured during the last elicitation are reported. The parameter values are reported separated for each different node (***Unrest*****,** ***Magmatic Unrest,*** and ***Eruption***). In case of partial anomaly, the affected parameters will be highlighted using orange text, while red is used for full anomalies. For each node, the probability distributions (cumulative distribution functions, CDF) quantifying the epistemic uncertainty on the **conditional probability** at each node are also plotted on top of the parameters list. For each CDF, also the main percentiles (16/50/84%) and the mean values are visualized.

4. Suite Log: in this tab, the suite execution log is presented, useful to monitor the processes and to debug the procedure.

5. User guide: in this last tab, the user can find this guide.

(*) Hazard map is meant as the map of intensity (e.g., tephra loading) whose probability of exceedance equals the defined probability threshold

References

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